Appendix B

Brock

Biology of Microorganisms

EIGHTH EDITION

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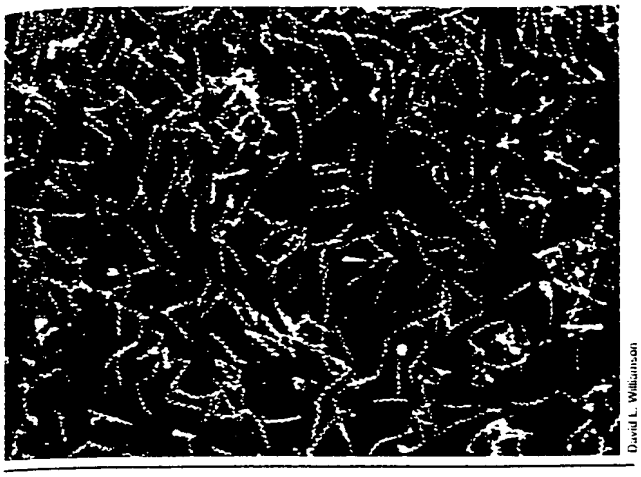

Figure 16.95 Dark-field micrograph of the "sex ratio" spiroplasma removed from the hemolymph of the fly *Drosophila pseudoobscura*. Female flies infected with the sex ratio spiroplasma bear only female progeny. Individual spiroplasma cells are about 0.15 μm in diameter.

and flagella, they are motile by means of a rotary (screw) motion or a slow undulation. Intracellular fibrils that are thought to play a role in motility have been demonstrated. The organism has been isolated from ticks, the hemolymph and gut of insects, vascular plant fluids and insects that feed on fluids, and the surfaces of flowers and other plant parts. *Spiroplasma citri* has been isolated from the leaves of citrus plants, where it causes a disease called *citrus stubborn disease* and from corn plants suffering from *corn stunt disease*. A number of other mycoplasma-like bodies have been detected in diseased plants by electron microscopy, which indicates that a large group of plant-associated mycoplasmas may exist. Four species of *Spiroplasma* are recognized that cause a variety of animal diseases such as *honeybee spiroplasmosis, suckling mouse cataract disease*, and *lethargy disease* of the beetle *Melolontha*.

CONCEPT CHECK 16.27

The mycoplasma group are organisms that lack cell walls and contain a very small genome. Many species require sterols to strengthen their membranes, and several are pathogenic for humans and other animals.

- ✔ *Where do the mycoplasmas group phylogenetically?*
- ✔ *Compare and contrast the genus* Mycoplasma *with the genus* Acholeplasma *in terms of growth requirements, genome size, and metabolism.*
- ✔ *Compare and contrast* Mycoplasma *with* Thermoplasma *in terms of metabolism, phylogenetic position, habitat, and pathogenicity.*

16.28

High GC Gram-Positive Bacteria: "Actinomycetes"

An extremely large variety of bacteria fall under this heading, as evidenced by the entire volume (Volume IV) of *Bergey's Manual*, which is devoted to the filamentous actinomycetes, and major portions of Volume II devoted to the rod-shaped relatives of this group. Phylogenetically, the actinomycetes form a subdivision of gram-positive Bacteria, distinct from the endospore formers and gram-positive cocci and asporogenous rods. Despite great morphological variability, the actinomycetes form a tight phylogenetic unit and most representatives have mole percent GC ratios in the 60s and 70s. There are considerable difficulties in drawing clear-cut distinctions between various genera of actinomycetes. Most of these organisms show a few common features: they are gram-positive, rod-shaped to filamentous, aerobic, and generally nonmotile in the vegetative phase (although motile stages are known). A continuum exists from simple rod-shaped organisms to rod-shaped organisms that occasionally grow in a filamentous manner, to strictly filamentous forms. Table 16.44 provides an overview of this group. In the following sections, we discuss some of the more interesting and important genera.

16.29

Coryneform Bacteria

The coryneform bacteria are gram-positive, aerobic, nonmotile, rod-shaped organisms with the characteristic of forming irregular-shaped, club-shaped, or V-shaped cell arrangements during normal growth. V-shaped cell groups arise as a result of a snapping movement that occurs just after cell division (called postfission snapping movement or, simply, *snapping division*) (Figure 16.96). **Snapping division** has been shown to occur in one species because the cell wall consists of two layers; only the inner layer participates in cross-wall formation, and so after the cross-wall is formed, the two daughter cells remain attached by the outer layer of the cell wall. Localized rupture of this outer layer on one side results in a bending of the two cells away from the ruptured side (Figure 16.97) and thus development of V-shaped forms.

The main genera of coryneform bacteria are *Corynebacterium* and *Arthrobacter*. The genus *Corynebacterium* consists of an extremely diverse group of bacteria, including animal and plant pathogens as well as saprophytes. The genus *Arthrobacter*, consisting primarily of soil organisms, is distinguished from *Corynebacterium* on the basis of a cycle of development in *Arthrobacter* involving conversion from rod to sphere and back to rod again (Figure 16.98, page 734).

TABLE 16.44 Actinomycetes and related genera (all gram-positive)[a]

Major groups	DNA (mol % GC)
Cornyeform group of bacteria: rods, often club-shaped, morphologically variable; not acid-fast or filamentous; snapping cell division	
Corynebacterium: irregularly staining segments, sometimes granules; club-shaped swellings frequent; animal and plant pathogens, also soil saprophytes	51–65
Arthrobacter: coccus–rod morphogenesis; soil organisms	59–70
Cellulomonas: coryneform morphology; cellulose digested; facultative aerobe	71–73
Kurthia: rods with rounded ends occurring in chains; coccoid later	36–38
Brevibacterium: coccus–rod morphogenesis; cheese, skin	60–67
Propionic acid bacteria: anaerobic to aerotolerant; rods or filaments, branching	
Propionibacterium: nonmotile; anaerobic to aerotolerant; produce propionic acid and acetic acid; dairy products (Swiss cheese); skin, may be pathogenic	53–68
Eubacterium: obligate anaerobes; produce mixture of organic acids, including butyric, acetic, formic, and lactic; intestine, infections of soft tissue, soil; may be pathogenic; probably the predominant member of the intestinal flora	26–48
Obligate anaerobes	
Bifidobacterium: smooth microcolony, no filaments; coryneform cells common; found in intestinal tract of breast-fed infants	55–67
Acetobacterium: homoacetogen; sediments and sewage	39–43
Butyrivibrio: curved rods; rumen	36–42
Thermoanaerobacter: rods, thermophilic, found in hot springs	37–39
Actinomycetes: filamentous, often branching; highly diverse	
Group I. Actinomycetes: not acid–alcohol-fast; facultatively aerobic; mycelium not formed; branching filaments may be produced; rod, coccoid, or coryneform cells	
Actinomyces: anaerobic to facultatively aerobic; filamentous microcolony, but filaments transitory and fragment into coryneform cells; may be pathogenic for humans or animals; found in oral cavity	57–69
Other genera: *Arachnia, Bacterionema, Rothia, Agromyces*	
Group II. Mycobacteria: acid–alcohol-fast, filaments transitory	
Mycobacterium: pathogens, saprophytes; obligate aerobes; lipid content of cells and cell walls high; waxes, mycolic acids; simple nutrition; growth slow; tuberculosis, leprosy, granulomas, avian tuberculosis; also soil organisms; hydrocarbon oxidizers	62–70
Group III. Nitrogen-fixing actinomycetes: nitrogen-fixing symbionts of plants; true mycelium produced	
Frankia: forms nodules of two types on various plant roots; probably microaerophilic; grows slowly; fixes N_2	67–72
Group IV. Actinoplanes: true mycelium produced; spores formed, borne inside sporangia	
Actinoplanes, Streptosporangium	69–71
Group V. Dermatophilus group: mycelial filaments divide transversely, and in at least two longitudinal planes, to form masses of motile, coccoid elements; aerial mycelium absent; occasionally responsible for epidermal infections	
Dermatophilus, Geodermatophilus	56–75
Group VI. Nocardias: mycelial filaments commonly fragment to form coccoid or elongate elements; aerial spores occasionally produced; sometimes acid–alcohol-fast	
Nocardia: common soil organisms; obligate aerobes; many hydrocarbon utilizers	61–72
Rhodococcus: soil saprophytes, also common in gut of various insects; utilize hydrocarbons	59–69
Group VII. Streptomycetes: mycelium remains intact, abundant aerial mycelium and long spore chains	
Streptomyces: Nearly 500 recognized species, many produce antibiotics	69–75
Other genera (differentiated morphologically): *Streptoverticillium, Sporichthya, Microcellobosporia, Kitasatoa, Chainia*	67–73
Group VIII. Micromonosporas group: mycelium remains intact; spores formed singly, in pairs, or short chains; several thermophilic; saprophytes found in soil, rotting plant debris; one species produces endospores	
Micromonospora, Thermoactinomyces, Thermomonospora	54–79

[a]Phylogenetically, all species (except for *Acetobacterium, Butyrivibrio,* and *Thermoanaerobacter*) fall into the high GC subdivision of the gram-positive Bacteria (⇒ Section 15.7).

However, some corynebacteria are pleomorphic and form coccoid elements during growth, and so the distinction between the two genera on the basis of life cycle is not absolute. The *Corynebacterium* cell frequently has a swollen end, so it has a club-shaped appearance (hence the name of the genus: *koryne* is the Greek word for "club"), whereas *Arthrobacter* is less commonly club-shaped.

Organisms of the genus *Arthrobacter* are among the most common of all soil bacteria. They are remarkably resistant to desiccation and starvation, despite the fact that they do not form spores or other resting cells. Arthrobacters are a heterogeneous group that have considerable nutritional versatility, and strains have been isolated that decompose herbicides, caffeine, nicotine, phenol, and other unusual organic compounds.